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APPLE DISEASES IN INDIANA

WITH SPRAY SCHEDULE

H. S. JACKSON

Every grower of apples realizes the importance of keeping the orchard in a healthy condition, not only with reference to the general vigor of the trees but also with respect to the control of diseases and insect pests. A number of very important diseases are known to occur which cause more or less damage to apple trees or fruit in Indiana. It is the purpose of this circular to furnish in condensed form, information regarding the character, cause and control of the more common and important fungous diseases of the apple, and general spraying directions for the guidance of Indiana orchardists. Several minor diseases of the foliage and fruit are known to occur in Indiana in addition to those included, but it has seemed best to omit them from this circular. Fire blight is discussed in another publication which will be sent free on request.[1]

Further information regarding the diseases covered in this circular, or of others not mentioned, concerning which growers may desire information, will be gladly furnished at any time. Address the Department of Botany, Purdue University Agricultural Experiment Station, LaFayette, Ind. It is always best when making inquiries concerning plant diseases, to send specimens. These should be ample, and so wrapped as not to dry out during transit.

APPLE SCAB [2]

This disease is perhaps the most important of those which affect the apple in Indiana, as is the case in most of the apple growing districts of the United States. It is relatively more important in the northern districts than in the southern, where blotch and bitter rot

[1] Durham, C. B. "Fire blight of apples and pears." Purdue University Extension Leaflet No. 63, 1915. See also, Jackson, H. S., "Fire blight control." Proceedings Indiana Horticultural Society, 1915. pp. 275-280, 1916

[2] Acknowledgment. In preparing the account of the diseases of apples which follow, the writer has drawn freely on all available sources of information, acknowledgment for the use of which is gratefully made. The writer is especially indebted to the Department of Plant Pathology, Cornell University, for the loan of prints from which Figs. 2, 6, 7, 9, 10, 13 and 14 were reproduced, and similarly to the Department of Horticulture, Purdue University for Figs. 3 and 8, as well as for helpful suggestions regarding control measures

may cause fully as much or in some cases perhaps greater losses. The damage from scab varies greatly from season to season, the prevalence of the disease being greatly influenced by weather conditions. The direct loss from scab is chiefly from the effect on the fruit, not only on account of the impairment in quality and market value because of the blemish, but also through loss in size as well as keeping qualities. The presence of the fungus on the foliage interferes with the normal function of the leaves and thus contributes to loss of vigor and growth. Affected leaves often fall prematurely, and when infection is abundant, partial defoliation may result.

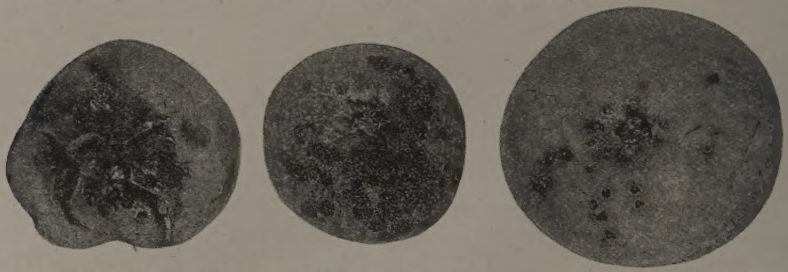

Fig. 1. Apple scab on the fruit showing various degrees of infection. Note the cracks developed as a result of severe infection on the fruit at the left (photo by Osner)

CHARACTER OF THE INJURY.—On the fruit the disease appears as circular; at first dark grey or olivaceous spots, which later become blackish. These vary in size from one-sixteenth to one-fourth inch in diameter or may be larger. The skin is ruptured and often appears as a white papery fringe surrounding the spots. These may occur anywhere on the apple, but commonly are more abundant on one side or near the calyx end. When attacked in an early stage of development, the fruit is often distorted and frequently becomes deeply cracked. Diseased fruit frequently does not develop to normal size and the more seriously affected fruits may drop before maturity.

On the leaves smoky brown patches develop occurring on either surface. Where many spots develop on individual leaves they may turn yellow and fall prematurely; often severe defoliation may occur. Sometimes the blossoms are affected, the spots appearing chiefly on the stalks and on the calyx. If the spot encircles the stem the young fruit withers and falls. When severe, this form of the disease may greatly reduce the set of fruit. Occasionally the twigs are attacked, but this is of rare occurrence.

CAUSE OF THE DISEASE.—Apple scab is caused by a fungus[1] the vegetative stage of which develops just beneath the cuticle of the parts affected, forming in the spots on the fruit, a mass of closely interwoven threads which become upright at the surface, and large

[1] Venturia inaequalis

Fig. 2. Apple scab on the leaves showing the appearance on both surfaces when the infection occurs on the upper surface

numbers of minute, brown spores are produced which serve to spread the fungus. On the leaves the fungus threads develop in the form of radial strands beneath the cuticle from which similar spores are developed in great numbers. When affected leaves drop to the ground in the fall, the fungus continues to develop and spreads throughout the tissue of the dead leaf, and in the spring another type of spore is formed in small, black receptacles. These spores are carried by the wind, and cause the first scab spots on the unfolding leaves. Spores are soon formed in these spots, by means of which, the fungus is spread to other leaves and fruit. This process is repeated so long as conditions are favorable for the development of spores and for infection.

Treatment: Apple scab may be controlled by spraying. Formerly Bordeaux mixture was used exclusively for controlling this disease. In recent years, lime-sulfur has come into more general use for some of the applications.

The regular applications for scab correspond to the *first, second,* and *third summer sprays* as outlined on pp. 22 and 23. These

should never be omitted. Under exceptional conditions, particularly if rainy weather prevails, the first two sprays may not properly control the spread of the fungus. If this condition is found to occur, an application intermediate between the regular second and third sprays, may be found desirable and should be put on about ten days or two weeks after the calyx spray. Use lime-sulfur diluted to one degree Baume. In seasons when abundant rains continue throughout June, the *fourth summer spray* (p. 23) may also be found to be important in scab control, particularly where susceptible varieties are grown.

RUST

The disease known as apple rust or cedar rust, is in some seasons of considerable importance in most of the apple growing districts of the State. This disease is more serious on certain varieties than others, the Rome Beauty being particularly susceptible. It is unique among apple diseases, in that the causal organism develops a portion of its life history on another host plant, the red cedar. If red cedars are not present in any locality, the disease will not be found on the apple.

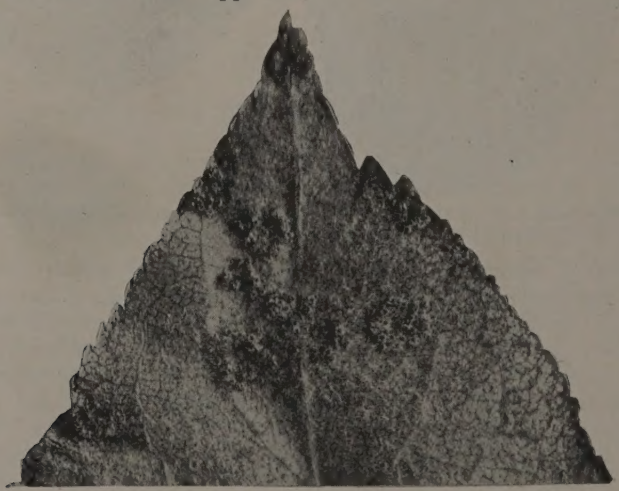

Fig. 3. Rust on apple foliage showing the appearance of the cup-like bodies on the under surface. Enlarged about twice the natural size

CHARACTER OF THE INJURY.—On the apple, the rust first appears on the upper surface of the leaf as light yellow spots, which soon turn to bright orange. Very soon there appear in the spots on the upper surface of the leaf, minute, yellow pustules which soon turn dark. Later, on the under surface, another more conspicuous structure is developed, which originates beneath the epidermis of

the leaf and finally ruptures it, and a cup-shaped structure is exposed, which is surrounded by a definite wall. This wall at first encloses the cup-like body but later becomes ruptured, splitting lengthwise, the lacerated parts becoming strongly recurved. The spots at maturity are considerably thickened and may occur in large numbers on a single leaf. The fruit is often affected in a similar manner. The spots, however, usually are large and only one or two develop on each fruit. In the great majority of cases the infection occurs at the calyx end. The tissue is usually thickened, and the affected fruit becomes deformed. If young apples are affected they are usually dwarfed.

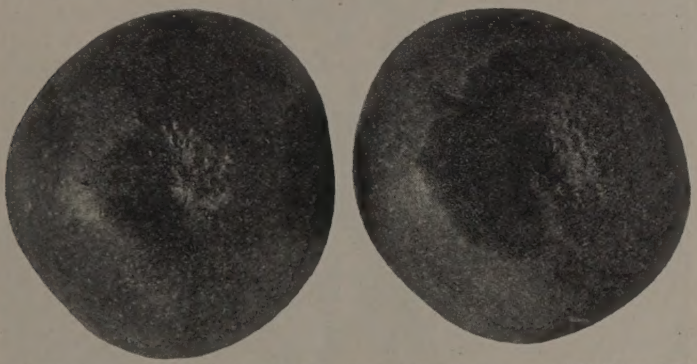

Fig. 4. Rust on apple fruit showing infection at the blossom end (photo by Osner)

On the cedar, gall-like structures are developed. These begin to appear in the late summer as light greenish swellings on the leaves which soon enlarge, turn brown and become kidney-shaped. In some cases they may reach a diameter of two inches by fall. Numerous depressions make their appearance in the galls as they reach their full size, from which, early in the following spring horn-like, brown projections develop. These may become an inch or more long, and in wet weather swell up, becoming gelatinous in consistency and turning pale orange.

CAUSE OF THE DISEASE.—The disease is caused by a rust fungus.[1] The horn-like bodies which develop on the cedar galls are composed of one of the spore stages of the fungus. These germinate in position when the mass swells in water, and smaller spores are developed, which are carried away by the wind. If these small spores come to rest on the leaves or fruit of the apple, they germinate and cause infection which results in the characteristic symptoms described above. In the cup-like structures on the under surface of the apple leaves or on the spots on the fruit, there are developed in great numbers another sort of spore, which is not capable of infect-

[1] Gymnosporangium Juniperae-Virginianae

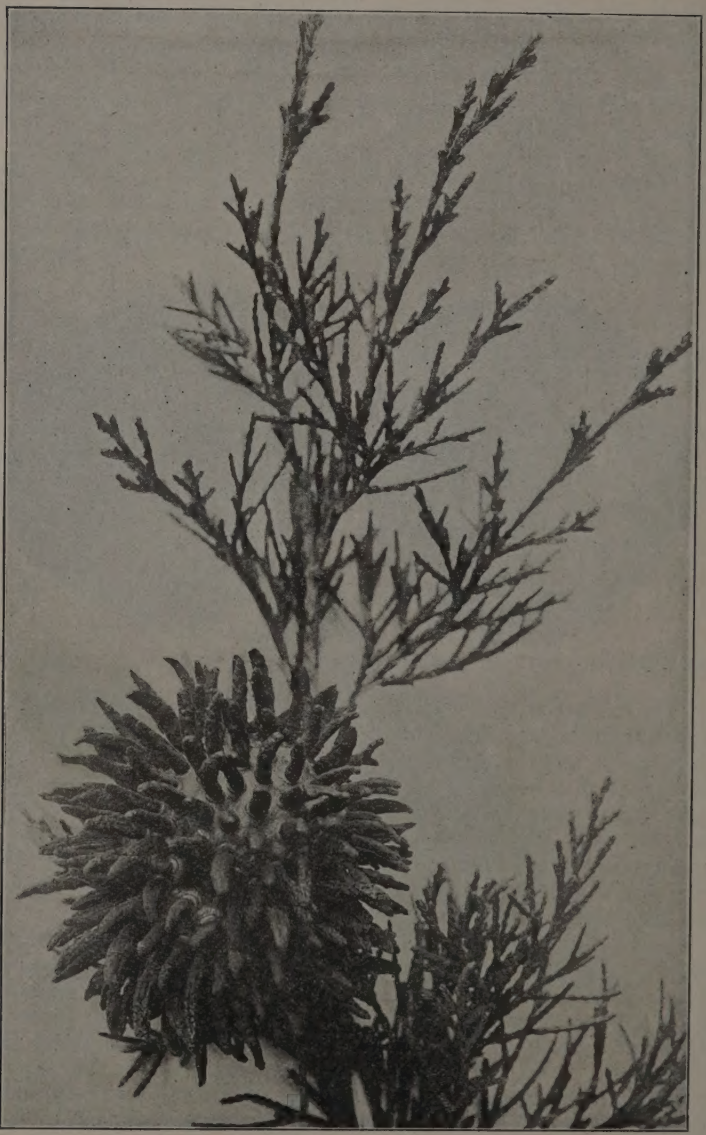

Fig. 5. Rust on the cedar. Note the horn-like bodies borne on the gall. Spores develop on these, which cause the infection on the apple (photo by Kern)

ing the apple again, but is carried by the wind to the cedar, where is produces infection in the late summer, finally resulting in the mature gall.

Only leaves in a certain stage of development are affected. The abundance of the disease on the apple is very closely associated with the weather conditions. In those years, in which frequent rains occur during the period of development of the sporidia on the cedar, the infections on the apple are very numerous, resulting often in partial defoliation or in infection of a large percentage of the fruit, rendering it unsaleable.

Treatment: Since the infection on the apple can only develop from spores borne on the cedar, it is clear that *if no cedars are present in the locality no rust will develop on the apple*. On this account, the simplest method of control is the removal of cedar trees from the vicinity of orchards. All cedar trees should be cut down within a radius of one mile of the orchard. This should be done in the winter. If cutting is done after March 1, the tops should be immediately burned, since it has been shown that the spores on the cedar galls may continue to germinate and be a source of infection for some time after the trees are cut.

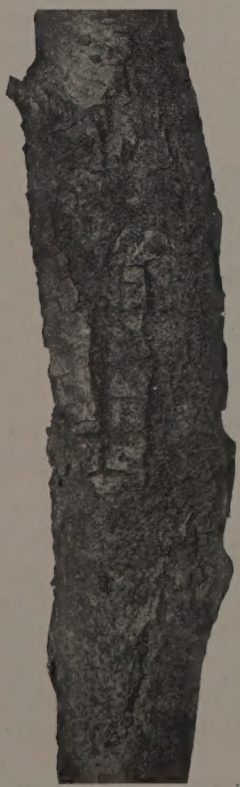

Fig. 6. Canker produced by the black rot fungus

Spraying is unreliable and not to be recommended. While it has been shown that cedar rust may be controlled experimentally by spraying, it is not recommended for the practical orchardist. To be effective the leaves must all be thoroughly protected as fast as they appear. This would necessitate more frequent sprayings than would be practicable.

When making new plantings avoid susceptible varieties.

BLACK ROT

This disease causes a canker of the branches, a spot of the leaves and a rot of the fruit. It is frequently referred to as the New York apple tree canker. It is one of the most important of the diseases of the apple and occurs generally throughout the eastern and middle western apple districts.

CHARACTER OF THE INJURY.—The cankers occur on the larger limbs, as a rule, and are found more frequently on the upper side. They start as reddish brown areas, which

gradually become sunken. A fissure or crack is soon formed, temporarily limiting the extent of the canker. As a rule, however, the canker continues to spread at one or more places along the side. These areas later also become limited by a growth of corky tissue and a fissure or crack develops, giving a characteristic appearance to the cankers. Sometimes the cankers die after the first season's growth, but ordinarily they continue to spread year after year. The bark usually remains firmly attached to the wood for a year or more, but finally drops out. Large branches are frequently girdled. In the bark of the cankers, there develop minute, black bodies, which are the fruiting stage of the causal organism.

On the leaves, characteristic spots are produced. These first appear as small, purplish dots, which soon enlarge and become yellowish brown. At first they are circular in outline and definitely limited, but later may extend at one side, finally presenting a lobed appearance. The older spots are irregular, and marked by concentric rings representing the irregular manner of growth. Small, black fruiting bodies may develop on the dead areas. In cases of severe infection the leaves turn yellow and fall, often resulting in considerable defoliation.

Fig. 7. Black rot on the fruit. Note the black specks on the fruit at the right. The infection has started in a worm hole on the left hand fruit

The rot on the fruit finally results in the complete death of the tissues, which remain firm and finally dry up, forming a mummy. The disease usually appears on apples approaching maturity or develops in storage. Often the disease starts at the blossom end or in a worm hole. The spots on the fruit are at first brown, often with concentric zones of lighter and darker areas marking the advancing stages of growth. The margin advances rapidly but is sharply defined from the healthy tissue. In later stages, the skin turns black, and black, fruiting bodies appear as minute elevations scattered over the affected area.

CAUSES OF THE DISEASE.—The black rot canker, leaf spot and rot are all caused by the same fungus,[1] which produces spores in

[1] Physalospora Cydoniae

small, black cavities in the dead tissues of the leaves and fruit, and in the bark of cankers. These spores serve to disseminate the fungus and produce new infections throughout the growing season. The fungus lives over winter in the bark of the cankers and spores formed early in the spring, serve to start the first infections. Spores are produced continuously throughout the summer in old cankers. The causal fungus occurs not only on the apple but on the pear, quince and a number of native trees and shrubs.

Treatment: Since the fungus lives through the winter in the bark of the cankers, the most important method of control is in cutting out the cankers. Where these are large, the entire limb should be removed. This work may be done during the regular time of pruning. Where practicable, the diseased bark may be removed without cutting off the branch. This is best done early in the spring, just before the buds swell. Great care must be exercised in pruning out the cankers. All the diseased bark must be removed and the wound carefully protected with pruning paints having asphaltum or coal tar as a basis, or with a thick paste of white lead and linseed oil. Where large branches are removed, the cut should be made close to the trunk or supporting branch so as not to leave a stub. The resulting wound should be smooth and likewise carefully protected.

Spraying should be practiced where the disease is troublesome on the fruit and leaves. The *first, second* and *third summer sprays* (pp. 22 and 23) as recommended for apple scab will control the leaf spot stage. The *fourth* and *fifth summer sprays* (p. 23) will control the rot of the fruit.

BITTER ROT

The disease known as bitter rot, sometimes referred to as ripe rot or anthracnose, is one of the most serious diseases of the apple in Indiana, particularly in the southern part of the State. It causes a rot of the fruit and also develops a canker on the limbs which is known as the bitter rot canker. The disease develops most abundantly in seasons when hot, moist or muggy weather prevails.

Character of the Injury.—The rot on the fruit appears late in the summer after the apples are well grown, and begins as a small, light brown discoloration beneath the skin, which enlarges rapidly. These spots gradually become blackish brown and usually retain a circular outline. Affected fruits remain firm, but as the rot develops, the tissue shrinks and the spot becomes depressed. When the spot is well developed, minute, slightly raised, blackish specks make their appearance, scattered irregularly on the surface of the rotted area or are often arranged in a concentric manner. These soon break open, exposing pinkish masses beneath. These bodies are the fruiting pustules of the causal fungus and continue to ap-

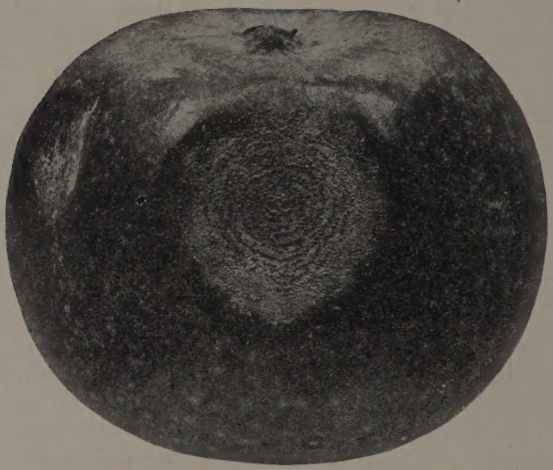

Fig. 8. Apple affected with bitter rot. Note the pustules of the fungus arranged in a concentric manner in the rotted areas

pear as the spot develops. The entire fruit ultimately becomes rotted and dries up and may fall or remain attached to the tree as a mummy.

The cankers are found on the fruit spurs, twigs and smaller limbs. Not infrequently cankers which develop on the younger twigs, may girdle them and produce a twig blight which might easily be mistaken for fire blight, unless examined closely. Cankers on large limbs usually result from twig infection which has run down into the branch. Infection may start on either live or dead twigs. Young cankers are oval in shape and the bark is characteristically discolored. They enlarge and become irregularly but definitely limited; as they grow older the bark is roughened and finally becomes cracked.

CAUSE OF THE DISEASE.—Bitter rot is caused by a fungus,[1] the vegetative stage of which develops in the tissues of the rotted fruit or in the bark of cankers. In the pustules referred to above, the spores which are pink in mass are developed. These are small, oval bodies produced in countless numbers and are washed and spattered about by rains or may be carried by insects. When they come to rest on the surface of fruit and bark, they germinate by the production of a minute thread, which penetrates the tissue and starts a spot or canker. The first infection doubtless arises from spores that have developed on mummies or cankers of the previous season. The growth of the fungus is rapid, and successive crops of spores may be produced throughout the season, if weather conditions are favorable to their development. It has been shown that

[1] Glomerella cingulata

Fig. 9. Characteristic bitter rot cankers

the fungus may also attack dead twigs or live in the bark of other cankers, such as the black rot canker or the blister canker. All such cases may develop spores which serve to cause infection on fruit or twigs the following spring.

Treatment: Since the cankers are the source of much of the infection which results later in the fruit rot, they should be removed, preferably by cutting off the branch on which the cankers

occur. All dead twigs and branches should be removed, whether killed by bitter rot or by some other disease. Spraying is effective for controlling the fruit rot and prevents the formation of new cankers. The first spraying should be applied before the blossom buds open, corresponding to the *first summer spray* (p. 22). The *third summer spray* should also be applied as a control for this disease. Lime-sulfur is not effective and Bordeaux mixture, 4-4-50 should be used. Subsequent applications should be made at frequent intervals, depending upon the weather conditions. As a rule the *fourth* and *fifth summer sprays* (p. 23) will be sufficient.

BLISTER CANKER

This is without doubt the most serious canker disease of the apple which occurs in Indiana. It is known to be particularly abundant in the southern part of the State. This disease is often called the Illinois canker. It inflicts injury to the trees by causing the death of large areas of bark on the large limbs, frequently girdling them, and not infrequently occurring on the trunk and killing the entire tree or producing large cankered areas.

Character of the Injury.—In the early stages, this disease is somewhat difficult to distinguish from other cankers. At first, the diseased bark presents a dingy brown appearance. The bark is not completely killed at once over the entire affected area, but streaks or patches of healthy bark are found scattered throughout the canker, which on this account presents a characteristic, mottled appearance. The margin of the diseased area is definite and frequently a crevice is formed at the junction of the healthy and diseased bark.

Over the diseased area, the bark is usually somewhat depressed, due to shrinkage. Later in the summer and fall, small, tan colored cushions develop beneath the bark, which finally become exposed by the cracking of the outer layers. In older cankers, the bark turns blackish and appears as though burned. The dead bark is dry and brittle and falls away in patches, exposing the wood. The tan colored cushions turn darker in color and persist after the bark falls out. This gives a characteristic, blistered appearance to the cankers, a condition from which the disease takes its name. These cushions are often referred to as "nail heads" by the growers.

In severe cases, entire trees are stripped of bark. The cankers may extend from the ground to several feet above, on the larger branches, often affecting only one side of the tree.

Cause of the Disease.—The blister canker is caused by a fungus,[1] the vegetative stage of which develops in the bark and wood, killing the tissues as it progresses.

During the late summer of the first season's growth of a canker, the fungus produces masses of mycelium under the bark, which de-

[1] Nummularia discreta

Fig. 10. Apple branch affected with blister canker. Note the round fruiting bodies of the fungus

velop into the tan-colored bodies previously mentioned. On the surface of these, reproductive bodies known as spores are produced, which doubtless serve to disseminate the fungus. During the early part of the following season, there develop in these tan-colored bodies, flask-shaped cavities, in which another type of spore is borne. These escape through definite openings and are scattered by various agencies. This, the so-called perfect stage of the fungus, is doubtless most important in spreading the disease.

Infection occurs only through wounds, especially such as expose the wood. Stubs left in careless pruning are responsible for a large number of infections.

The fungus is known to develop extensively in the heart wood and it is possible that it is able to break out at other points on an infected branch, if other wounds exposing the heart wood occur. The fungus is capable of developing from old cankers year after year extending the area originally infected.

Treatment: On account of the method of growth of the causal fungus, this is one of the most difficult canker diseases to control. When the fungus is well established in the heart wood, it is practically impossible to eradicate it. Badly diseased limbs should be removed. When young cankers are observed in the early stages of development, the diseased bark should be carefully and completely removed and the exposed wood kept covered with some good wound dressing. Since the fungus can obtain a foothold only through injured bark, care should be taken to prevent wounding the trees, or when wounds occur accidentally, they should be carefully dressed. In pruning, avoid leaving any stubs and protect all cuts with coal tar or pruning paints having asphaltum as a basis, or cover all cut surfaces with a thick layer of white lead and linseed oil. All brush removed from an orchard, whether healthy or diseased, should be burned and not left in piles to rot.

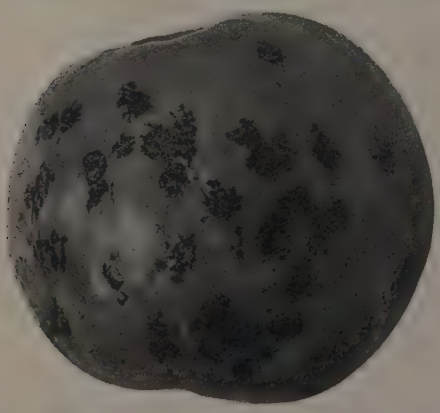

Fig. 11. Apple blotch on the fruit. Note the irregular character of the spots. Compare with Fig. 1 (photo by Osner)

BLOTCH

This important disease of apples is most prevalent in the southern states. As in the case of bitter rot it is most abundant in the orchards of southern Indiana. The fruit is affected in such a way as to greatly reduce the quality or render it unmarketable. The disease also attacks the twigs, causing cankers,

which in severe cases may kill small twigs or branches. The leaves also are affected, the disease showing as small spots. In severe cases, partial defoliation may occur or the leaves may die and cling to the tree.

Character of the Injury.—On the fruit, the disease at first appears as very small, light brown blotches, which increase in size to one-half inch with an irregular margin presenting a fringed or stellate appearance. Often several spots may unite to form large, brown blotches which may involve the greater part of the surface of the fruit. Only the outer layers of tissue are affected. When severely affected, the fruit often cracks. The spots are more diffused than is the case of those due to apple scab. In the blotches there may be seen a few small, black specks which are the fruiting structures of the causal organism.

Fig. 12. Apple twigs showing the characteristic rough cankers caused by the apple blotch fungus (photo by Osner)

On the twigs and fruit spurs, the disease causes characteristic cankers. The young cankers appear as small, purple or blackish, raised blotches, which increase in size and turn brownish in the center, later becoming grey and somewhat sunken. A crack is

found surrounding the cankers. In older cankers, the bark becomes very much cracked and presents a very rough and scurfy appearance. The black, fruiting bodies of the causal fungus make their appearance in the late summer and fall, on the diseased bark as minute, black dots. Cankers may continue to grow for several years, the disease extending from the margin of the canker of the previous season, or in some cases may become limited after the first season's growth.

The spots on the leaves are small, seldom reaching a diameter of over one-sixteenth of an inch. They are irregular, light brown or yellowish in color. The spots are scattered and may occur in great numbers on the affected leaves. In the spots are developed one or more of the blackish fruiting pustules of the fungus, causing the disease. Often spots develop on the petioles, girdling them and resulting in the death of the leaf, which in such cases remains attached to the tree for some time. Where the spots are abundant on the leaf blade, considerable defoliation may occur.

Cause of the Disease.—The apple blotch is caused by a fungus[1] which develops in the affected tissue of the fruit, leaves or in the bark of cankers, killing the tissues as it progresses. The fungus reproduces itself by means of minute ellipsoid spores which are borne in flask-shaped or spherical cavities. These are black and develop beneath the epidermis, raising it slightly and forming the pustules mentioned above. No other fruiting structure is known to occur. The fungus lives over winter in the cankers. In the spring, the fungus renews activity and spores are produced which when disseminated by wind and rain, or possibly also by insects, serve to start infection on foliage and fruit. Spores are also produced in abundance in the affected parts during the summer, and serve to spread the disease rapidly during the growing season.

Treatment: Since the disease hibernates in the bark of cankers, it is important that all seriously affected twigs be removed in the early spring. The third, fourth and fifth summer sprays recommended on p. 23 will be found to control this disease satisfactorily. Bordeaux mixture 3-4-50 should be used for the fourth and fifth applications in place of the stronger mixture.

XYLARIA ROOT ROT

A root rot recently recognized in certain sections of the eastern United States has been reported from southern Indiana. The importance of the disease in this state is not well known, although it is highly probable that much of the trouble from root rot reported in Indiana is due to this disease.

Character of the Injury.—The effect of this disease is usually first observed in the foliage. When trees are but slightly affected, the leaves appear normal but are fewer in number than on

[1] Phyllosticta solitaria

healthy trees. When the disease on the roots has developed to some extent, the foliage is smaller than on normal trees. In all stages, more or less yellowing of the foliage is also apparent. Frequently diseased trees set an excessive number of fruits which remain small and ripen prematurely. Seriously infected trees often show a decided inclination to lean away from the side where the roots are affected most seriously.

The roots of diseased trees are at first found to be covered by a thin, compact layer of a white mold-like growth, the outer portion of which soon changes to a black incrustation. Small, black strands may also be seen extending in all directions from the margin of the black incrustation. These often unite to form a network. The bark beneath the fungous growth decays rapidly. In later stages, cracks develop in the dead bark. The disease progresses slowly but finally the roots are girdled. Not all of the roots of the tree may be affected at first and when girdled, new roots may be thrown out above, thus enabling the tree to live for a number of years after the infection starts. In some cases black, upright, club-shaped structures one to three inches in height which are the fruiting stage of the causal fungus may develop about the crowns of diseased trees, or from roots which are close to the surface of the ground.

Cause of the Disease.—This root rot is caused by one or more species of the fungus Xylaria. The vegetative stage forms the mold-like growth and the incrustation described above on the surface of the bark, and also develops in the tissue of the bark and wood, causing rapid decay in the bark and a slow disintegration of the wood. The fungus reproduces itself by means of spores borne on or in the club-shaped bodies.

Treatment: No method of treatment has been as yet worked out. When trees have contracted the disease there is little hope of saving them. It is probable that the disease is spread to some extent through cultivation. Where the roots of diseased trees come in contact with healthy ones, the fungus may spread from tree to tree underground. Badly diseased trees should be removed and burned, including as much as possible of the root system. Another tree should not be immediately set in its place. Where it is desired to retain a tree that is known to be diseased, it would doubtless be well to isolate it from others by digging a trench about the tree as is recommended for the mushroom (Armillaria) root rot. This method consists in digging a trench about one foot wide by two feet deep near the end of the root system surrounding the tree and throwing the earth toward the tree.

The "aeration" method also recommended for the control of mushroom root rot should also be tried when trees are discovered in an early stage of the trouble. This consists in exposing the crown and larger roots in the early summer, removing all badly diseased roots and bark and leaving them exposed during the summer. In

the fall, the wounds should be covered with pruning paint having asphaltum or coal tar as a basis, and the earth replaced.

Where diseased areas including a number of trees are found in the orchard, it would be desirable to withhold cultivation within that area so as to reduce to a minimum the possibility of spreading the fungus. In making new plantings, newly cleared land should be avoided, as it is well known that species of Xylaria are commonly found growing on decaying stumps and buried wood.

The above are merely suggestive methods; the disease must be further investigated before positive recommendations can be made. Growers are urged to report cases of the disease to the Department of Botany.

SOOTY BLOTCH AND FLY SPECK

The disease known by the above name, while not a serious trouble, is very common on certain varieties, particularly in seasons when late summer rains are abundant. The injury is superficial and the fruit is not appreciably injured except in appearance.

Character of the Injury.—The disease is characterized by the development of sooty blotches and black specks on the surface of the fruit. The blotches are at first pale in color, later turning sooty brown or black. They are one-fourth to one-half inch in diameter, and irregular in outline, although tending to be more or less circular. The blotches often unite and frequently nearly the

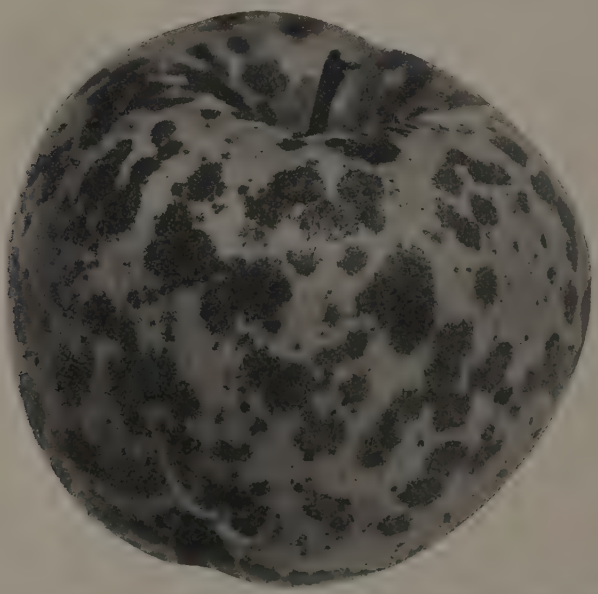

Fig. 13. Apple fruit showing characteristic appearance of sooty blotch

entire surface of the fruit is involved. The fly speck condition usually develops later and is characterized by groups of black, shiny dots resembling fly specks.

Cause of the Disease.—The blotches are produced by the growth of the vegetative portion of a fungus[1] on the surface of the fruit or in the cuticle. The growth proceeds in a radiate manner from the center of infection. It is believed that bits of the mold may break away, and coming to rest on injured surfaces, start new spots, thus serving to spread the fungus during the summer. The black specks are resting bodies of fungous tissue which are believed to carry the fungus over the winter. In these black specks, cavities develop in the spring that bear spores which serve to start infection. It is believed also that the fungus may hibernate on the twigs.

Treatment: This disease will not develop seriously on trees that are sprayed for scab or bitter rot or blotch, and where the treatment recommended for those diseases is followed, no special measures are necessary.

BITTER PIT OR STIPPEN

This disease is often referred to as Baldwin fruit spot on account of the prevalence of the disease on that variety. It is, however, common on other varieties as well. It is known to occur wherever apples are grown and is one of the most serious of fruit diseases.

Character of the Injury.—The disease appears only on the fruit and is characterized by the presence of slightly sunken, brown spots scattered over the surface but occurring most abundantly at the blossom end. At first they appear as more highly colored spots than the surrounding color. On red apples, the spots are at first darker red, on green apples darker green; finally, however, they all become brown. Spots are also found scattered through the flesh of the fruit associated with the fibrous or water conducting tissue. The flesh beneath the surface spots or surrounding the centers of internal spots is dry, dead and brown.

Cause of the Disease.—The bitter pit is not caused by an organism but is considered to be the result of some disturbance in the uniformity of the water supply. The exact nature of the cause is not known. It is believed by some authorities to be due to abundant transpiration or loss of water from the fruit, bringing about a concentration in the cell sap which results in the death of the cells, particularly in those at the ends of the water conducting tissue near the skin of the fruit or along the conducting system in the flesh. Others believe it is due to a bursting of the cells caused by too great pressure, brought about by excessive transpiration during warm days, which is checked during cool nights while the roots

[1] Leptothyrium Pomi

remain active in absorbing water, since the soil cools more slowly than the air. Other theories less plausible are held by some authorities.

Treatment: On account of the nature of the disease and lack of exact information regarding it, no very direct control measures can be given. The system of orchard management practiced will have a very important bearing on the prevalence of the trouble. Any methods of culture which will tend to favor the production of

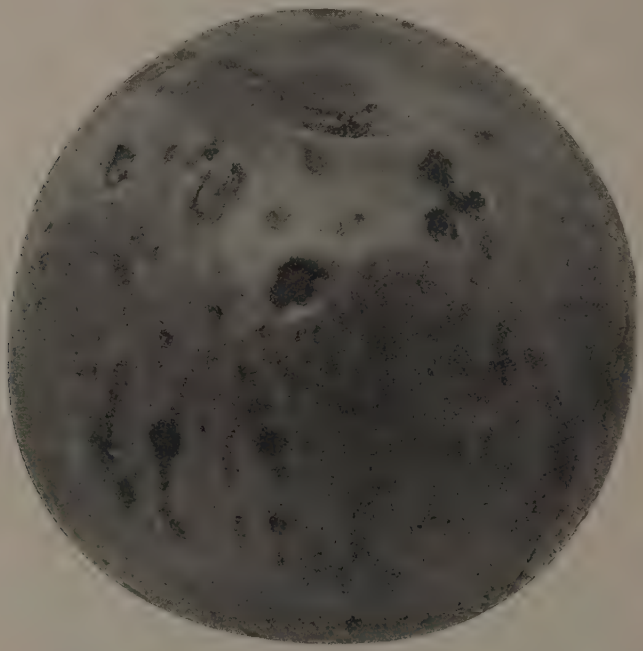

Fig. 14. Apple affected with bitter pit

good crops of evenly distributed fruit and normal, uniform growth of the trees should be practiced. The methods of pruning, cultivation and fertilization should be planned with this end in view. Every effort should be made, through attention to drainage, cultivation, and the use of cover crops, to provide a uniform and adequate supply of moisture throughout the growing season.

Fruit pit may develop in storage if proper conditions are not provided. It is found, however, that the trouble will not develop if the temperature is kept at 30 to 32 degrees Fahr.

GENERAL SPRAYING RECOMMENDATIONS

Spraying is now recognized as perhaps the most important orchard operation connected with the successful growing of high grade apples. It should not be assumed, however, that spraying is a "cure-all." Spraying may be only a part of the necessary procedure to control certain troubles, and there are some important diseases and insect pests which must be combated in some other way than by spraying. There are also important troubles for which no definite remedy has as yet been devised.

It is highly important that spraying for any pest be made at just the proper time, with just the right spray materials. Each pest, whether a fungus or an insect, has its own particular life history and particular time when it attacks the tree. This life history determines the method of treatment; consequently every grower must study orchard conditions in his district and must be familiar with the pests which occur there, in order that he may practice the proper method of control.

Timeliness of application is one of the essentials of successful spraying. The proper spray applied out of season will not be effective; neither will the wrong spray applied at the right time for some particular pest be successful. It is equally useless to expect one spray with any substance to prove effective for all kinds of pests.

Thoroughness of application is also essential to successful spraying. The object of spraying is either to kill the pest or parasite by hitting it with a spray mixture, at a time when it is unprotected or to coat all the branches, twigs, foliage and fruit of a tree so thoroughly with a fungicide or insecticide that there is no spot left unprotected, through which a disease producing fungus or an insect pest may be able to enter and cause damage.

SPRAY SCHEDULE

While the recommendations for the control of each individual disease or insect pest do not vary to any appreciable extent in different sections of the country, it is necessary in the interest of economy and efficiency, to work out a spray schedule to fit local conditions. The nature of this schedule is primarily dependent on the diseases and insect pests which occur in any given locality. An accurate knowledge of what pests occur, together with an understanding of sprays and spray mixtures, will enable any grower to work out an ideal schedule for his locality. The following general schedule[1] has been prepared for use in Indiana, and has been

[1] Adapted from Bulletin No. 194, Purdue Experiment Station. This bulletin deals with "The Indiana farm orchard, operating costs and methods," and contains an account of spraying methods, preparation of sprays and cost of spraying in Indiana, besides valuable information regarding the care and operation of the apple orchard and the marketing of the product. The bulletin will be sent free on request

thoroughly tested by the Department of Horticulture of the Purdue Experiment Station through a period of years, and found under ordinary conditions, to meet the needs of apple growers in the State.

Suggestions for deviation from this schedule under special conditions are given in the paragraphs on treatment in connection with the discussion of the diseases.

DORMANT SPRAY.—This spray is intended as a general sanitary measure for the control of scale. It is also of considerable value in killing the eggs of apple aphis and certain other insects. Certain canker diseases are also partially controlled by this application.

Use concentrated lime-sulfur diluted to test 5 degrees Baume. This is approximately equivalent to diluting high grade commercial lime-sulfur with eight times its volume of water.

Apply any time from November until the time for the buds to begin to swell. Advantage may be taken of mild weather in January, but it is not advisable to spray in freezing weather. It is very important that every twig, as well as every inch of bark on the branches and trunk, is thoroughly coated with the spray.

FIRST SUMMER SPRAY.—This is the most important application for the control of apple scab and is useful for controlling curculio, canker worms, bitter rot, etc. Bordeaux mixture 4-6-50 should be used, to which should be added one pound of powdered arsenate of lead or two pounds of paste to each 50 gallons of the mixture.

Make this application just before the blossom buds open. The most ideal time is after the blossoms are well separated in the cluster but before the first blossoms open. This is often impossible where a large acreage is to be sprayed, as the buds often develop rapidly and the trees are in bloom in a short time. On this account, it is often necessary to begin spraying just after the leaf buds burst and the first leaves of the fruit spurs are expanded. The size of the orchard and age of the trees as well as the weather conditions, must be considered in determining the exact time to begin spraying, in order to finish before the first blossom buds open. Varieties differ considerably in the time of blooming and the fact should be taken advantage of in spraying an orchard of mixed varieties.

SECOND SUMMER SPRAY.—This spray is important in controlling apple scab and is most essential for controlling the first brood of codling moth. Use lime-sulfur solution diluted to one degree Baume. This is approximately obtained by diluting five quarts of commercial lime-sulfur solution with 50 gallons of water. To this must be added arsenate of lead as recommended above for the *first summer spray.*

This spray should be applied as soon as the petals fall and before the calyx cup closes. A few days after the petals fall, the calyx lobes which have remained expanded during the blooming period, turn upward, effectually closing the calyx cup. Since the great majority of the apple worms which hatch from the eggs of

the codling moth, enters the apple at the calyx end, it is evident that this spray must be applied before the calyx cup closes so that some of the spray material may be forced into the cup.

In large orchards where the spraying equipment is limited, it is often advisable to begin making this application before all of the petals have fallen. The grower must be cautioned, however, against spraying while the flowers are in full bloom or before pollination is completed. If this is done, injury may result to the blossoms, or there is danger of killing large numbers of bees which are helpful in insuring pollination.

If plant lice are present on the leaves, these may be controlled by adding one-third of a pint of nicotine sulfate to each 50 gallons of spray solution.

THIRD SUMMER SPRAY.—This spray is for the purpose of controlling the second brood of codling moth, the curculio, lesser apple worm, the leaf spot stage of black rot, bitter rot, etc. It is also important in controlling fruit infection of scab, and is the first regular spray for the control of apple blotch. In those sections of the State where the blotch and bitter rot are present, or in orchards that are just being renovated, it is advisable to use Bordeaux mixture and arsenate of lead as recommended for the *first summer spray*. In orchards that have received regular sprayings in previous years, in sections of the State where bitter rot and blotch are not troublesome, the lime-sulfur and arsenate of lead as recommended for the *second summer spray*, may be used if preferred.

This application should be made about three weeks after the petals fall.

FOURTH SUMMER SPRAY.—The purpose of this application is to control bitter rot, blotch, curculio, etc.

Bordeaux mixture and arsenate of lead should be used as recommended for the *first summer spray*. The Bordeaux should be used, however, in a weaker strength. The 3-4-50 formula is recommended. The proper time to apply this spray varies in different sections of Indiana. In the northern part of the State, it is usually applied during the last week in June, while in the southern sections it is applied during the first week in July. It is important that special effort be made to thoroughly coat each fruit with the spray.

FIFTH SUMMER SPRAY.—The primary object of this spray is to control the late brood of codling moth, the apple blotch, bitter rot and sooty blotch and fly speck. This is one of the most important sprays of the season in sections where blotch and bitter rot are prevalent. The previous efforts to control these troubles may be rendered useless in a short time if this spray is omitted and favorable conditions for infection prevail. As is the case with the *fourth summer spray*, the primary object is to protect the fruit, so the application must be very thoroughly made.

Use Bordeaux mixture 3-4-50 and arsenate of lead and apply about three or four weeks after the *fourth summer spray*.